Michigan. Bureau of Maternal and Child Health

A MATERNAL, STILLBIRTH AND NEONATAL MORTALITY SURVEY
Grand Rapids, Michigan
1937 - 1939

The Committee on Maternal Health of the Kent County Medical Society, early in the spring of 1940, requested the assistance of a surveyist to review the maternal mortality for the city of Grand Rapids, Michigan. The Bureau of Maternal and Child Health of the Michigan Department of Health provided the services of an obstetrician for this purpose. The survey was to include both maternal mortality, some pertinent notes upon stillbirths and infant mortality as well as a review of the cesarean sections for the city.

The data was gathered in the summer and early fall of 1940. The amount of data obtained permits the issuance of two studies - one entitled, "Maternal, Stillbirth and Infant Mortality Survey, Grand Rapids, Michigan, 1937 to 1939", while a second companion paper will be devoted exclusively to "Cesarean Section Survey, Grand Rapids, Michigan, 1935 to 1939.

The estimated corporate population of the city of Grand Rapids, Michigan, at the time of this survey, was 176,000 individuals. This figure was provided by the officials of the Grand Rapids City Health Department.

The same authorities furnished the following table (Table I)

Table I
Births in Grand Rapids, Michigan*
1935 - 1939

Year	Live Births	Birth Rate	"Adjusted" Births	Adjusted Birth Rate	Still-births	Adjusted Stillbirths
1935	2672	15.2	2551	14.5	96	79
1936	2626	14.9	2520	14.3	95	85
1937	2896	16.4	2697	15.3	84	74
1938	3007	17.1	2803	15.9	89	72
1939	2895	16.4	2673	15.2	82	72
Totals	14096		13244		446	382

The term "adjusted" births was apparently used to connote "corrected" number of births, i.e. the non-resident patients are not included. Further it implies that those resident patients of Grand Rapids delivered elsewhere are allocated back to the Grand Rapids statistical tables after being subtracted from other nearby city tables (therein designated as non-residents). Therefore, "adjusted births" indicates the number of Grand Rapids women, resident of that city, delivered in Grand Rapids plus the number of Grand Rapids women, resident in that city but delivered elsewhere and allocated back to Grand Rapids tables.

*Table supplied by City of Grand Rapids Health Department

The close proximity of a large hospital to the corporate boundaries of Grand Rapids, but actually outside its city limits, requires much "statistical juggling" of numbers. In the effort to permit a comparison of numbers between the city health department annual reports, the state health department annual reports, and the figures of this survey, an attempt will be made to adhere to the aforementioned cumbersome statistical arrangement.

There were 14,096 unallocated births in Grand Rapids city in five year period 1935 to 1939. Correction of this number, to determine resident deliveries, by a subtraction of non-resident deliveries in the city plus the addition of city resident deliveries allocated back to the city, reveals that there were 13,244 "adjusted" live births in Grand Rapids during this five year period. In this five year period there were 446 stillbirths which when "corrected" by above technique leaves a total of 382 "adjusted stillbirths".

Inasmuch as the relatively intricate ramifications of statistical detail detract from clarity this report will use as few "corrected" figures as is possible. After all, so many babies were born in Grand Rapids! The doctors are concerned not with allocation, save in isolate instances, but rather with the relation of fatalities to total number of deliveries affected under their supervision and responsibility. In short, the physicians are more interested in "how many times did the axe slip while they were chopping a cord of wood". They are not concerned, save in few instances, with the problem, "Where did the cord of wood come from?" Unless, of course, a most unusual number of "feet are cut in the act of wood chopping"! In the latter event details will be supplied.

It was observed that the birth rates for 1937-38 and 1939 were higher; that the maternal mortality for this three year period was relatively lower (e.g. according to state accepted reports as 11 maternal deaths in 1937; as 3 maternal deaths in 1938; and as 5 deaths in 1939) than in preceding years. Therefore, the first paper was limited to a three year study. By such procedure more time was gained to review the neonatal deaths and stillbirths for this period and to correlate these to this obstetrical survey.

The apparent excellent record of Grand Rapids, as related to other large Michigan cities, is given in Table II. Note that this city ranks as the second largest city in the state of Michigan, as related to the safety of mothers in labor. It has been reported that the maternal death rates for these three years were 3.73 for 1937; 0.97 for 1938; and 1.68 for 1939.

Table II
The Comparative Maternal Rates* of Eleven Michigan Cities
1935 - 1939

City	Five Year Maternal Mortality Rate	Ranking	City	Five Year Maternal Mortality Rate	Ranking
Bay City	2.66	1	Jackson	4.11	7
Grand Rapids	3.09	2	Detroit	4.25	8
Lansing	3.60	3	Battle Creek	4.55	9
Kalamazoo	3.71	4	Flint	5.18	10
Muskegon	3.79	5	Pontiac	5.58	11
Saginaw	3.80	6			

*The gross figures for the calculation of these rates were obtained from the five annual reports of the Michigan Department of Health.

There were 8798 deliveries in Grand Rapids, Michigan, prior to the allocation of this number by health authorities, in the three year period, 1937 to 1939. Adjustment of statistics reveals 7573 deliveries of resident patients of live babies.

Forty seven (47) maternal deaths due to direct obstetrical complications or incidental to pregnancy itself occurred in Grand Rapids during this three year interim. This number represents both resident and non-resident cases - thereby the maternal mortality for Grand Rapids, prior to allocation by residence, was 5.34 per thousand live births. This number is a gross figure. It is higher than that obtained by using the number of maternal deaths as listed in other reports. The reason for this follows.

The increased number of maternal deaths was obtained in a tedious but relatively more accurate manner. All the death certificates of each of the three years were reviewed and in addition to actual listed maternal deaths all death certificates of women between ages of 15 to 50, which suggested or implied by "cause of death as listed" as a suspect case, these cases were temporarily added. The place of death was noted and, if in hospitals or in the home, the actual case records of private doctors or hospitals were interviewed or reviewed. If the demise was due to obstetrical causes, although listed perhaps on death certificate as "peritonitis" or "pneumonia" or "jaundice", it was thereafter included in total number of maternal deaths. In the case of infant deaths, the numbers involved were sufficiently large as to preclude individual perusal of every hospital record or doctor interview save for those born from fatal obstetric cases.

The distribution of maternal deaths by year and place of death is illustrated in Table III.

Table III
Maternal Mortality Survey
Grand Rapids, Michigan, 1937 - 1939

Year	Institution				
	Hospital A	Hospital B	Hospital C	Other*	All City
1937	6	3	10	3	22
1938	4	0	5	1	10
1939	5	1	9	0	15
Totals	15	4	24	4	47

Inasmuch as the number of live births previously mentioned was not wholly accurate as it apparently did not include full details of one of the three hospitals, located in East Grand Rapids, a separate table was constructed. This deals only with the 43 hospital maternal deaths and the total live births in each institution.

*Others - preponderantly "home" deliveries although other smaller obstetric institutions are included under this legend.

Table IV
Maternal Deaths in Hospitals*
Delivering Majority of Grand Rapids Obstetric Cases
1937 - 1939

Year	Hospital A Live Births	Mat. Deaths	Mat. Mort. Rate	Hospital B Live Births	Mat. Deaths	Mat. Mort. Rate	Hospital C Live Births	Mat. Deaths	Mat. Mort. Rate	All City Hospitals** Live Births	Mat. Deaths	Mat. Mort. Rate
1937	803	6	7.4	500	3	6.0	689	10	14.5	1992	19	8.5
1938	818	4	4.9	530	0	---	754	5	6.6	2102	9	4.2
1939	900	5	5.5	551	1	1.8	722	9	12.4	2173	15	6.9
Total 3 yrs.	2521	15	5.9	1581	4	2.5	2165	24	11.1	6267	43	6.8

It was obvious that the maternal mortality rates of the hospitals would be greater than that of the entire city. It was of especial noteworthiness to observe, however, that in the case of hospital B the maternal mortality was lower, by nearly 50%, than that of the city. The physicians in this hospital are to be complimented upon their unusual record of 1581 live births with but 4 maternal fatalities, a maternal mortality rate of 2.5 per 1000 live births, or but one fatality to each 400 deliveries.

Conversely hospital C reports a maternal mortality rate approximately four and one half times as great as hospital B and while the former delivered but approximately 200 more cases annually than the latter during this three year interim. Contrast 530 successful deliveries in 1938 without a single fatality (hospital B) to 689 deliveries with 10 fatalities (hospital C) in 1937, just one year removed. However, in fairness it must be admitted that the year 1937 was decidedly the more unsafe for mothers than either of the succeeding years. This statement holds true for hospitals A and C.

Allocation of Maternal Deaths by Residence

There were 26 maternal deaths among the resident patients and 17 maternal deaths among the non-resident cases in the 43 hospital deliveries. The distribution appears in Table IV.

Table IV
Residence Allocation of Maternal Deaths
Grand Rapids, 1937 - 1939

Residency	Institution Hospital A	Hospital B	Hospital C	Other (Home)
Resident	9	3	14	3
Non-Resident	6	1	10	1
Totals	15	4	24	4

*Prior to allocation by residence. Number of live births furnished by hospitals.

Includes one hospital, outskirts of Grand Rapids, where considerable Grand Rapids cases are delivered and is therefore included in this survey and under this legend (All City)

If the total live births, as reported by Grand Rapids City Health Department, is 8798 deliveries for these three years and the "adjusted" live births is assumed to be a subtraction of the "non-residents" from the total live births we find that there must have been but a total of (8798-7573=) 1225 non-resident deliveries in Grand Rapids for three years 1937 - 1939. Therefore, the maternal mortality rate of resident patients was 3.4 per 1000 live births while the maternal mortality rate of the none-resident cases was four times greater than that for resident cases, namely 13.8 per 1000 live births. Such a finding was anticipated.

The number of non-resident patients per each hospital was not obtained. Hence, the variations in these 2 types of patients, resident and none-resident, could not be determined for each institution. It was observed, however, that one "home" maternal fatality occurred in the non-residency allocation. This patient, whose home was outside of Grand Rapids, returned to her parents' home within the city and died there from embolism following her discharge after delivery from hospital B.

The Age and Parity of the Maternal Fatalities

The age incidence distribution of the 47 maternal fatalities is shown in Table V.

Table V
Age Incidence 47 Fatal Obstetric Cases

Age		Age	
16 to 20 -	5 cases	36 to 40 -	4 cases
21 to 25 -	14 cases	41 to 45 -	3 cases
26 to 30 -	14 cases	Total	47 cases
31 to 35 -	7 cases		

Thirty-three cases, 70%, of this group were 30 years of age or less while 7 patients, 15.2%, were 35 years of age or over.

There were sixteen primigravida patients in this series. Approximately one-third of this group died following delivery from their first pregnancy. Ten of the 47 patients had such inadequate histories that the details of their parity could not be determined. The remaining 37 cases gave their parity, exclusive of present pregnancy, as zero in 16 instances; para I in 7 instances; para II in 8 cases; para III in 2 cases; para IV in 3 cases; and para IX in 1 case.

The correlation of age incidence and parity of these 47 patients, who succumbed following delivery, is shown in Table VI.

Table VI
Correlation of Age Incidence to Parity
Maternal Mortality Survey
Grand Rapids, 1937 - 1939

	Parity						
Age Incidence	0	1	2	3	4	9	Unknown
16 - 20	3	-	1	-	-	-	1
21 - 25	5	4	1	-	-	-	4
26 - 30	8	-	2	2	-	-	-
31 - 35	-	3	1	-	2	-	1
36 - 40	-	-	1	-	1	-	2
41 - 45	-	-	2	-	-	1	-
Totals	16	7	8	2	3	1	10

Death Certificate Diagnoses

When the death certificate diagnoses of these 47 fatalities were reviewed the following enlightening observations were made. In the paragraphs below each diagnosis, as actually recorded, was fully accepted without critereae other than mere notation of cause of death as it was directly copied from the legal death certificate.

The broad term "TOXEMIA" might include some of these diagnoses: "eclampsia" in 4 cases; toxemia of pregnancy in 1 case; acute yellow atrophy of liver in 1 case; "nephritis with urinary suppression" in 1 case; acute hemorrhagic nephritis in 1 case; "acute nephritis" in 2 cases; "nephritic anuria" in 1 case; and "uremia" in 1 case. In summary, 12 instances under the general heading "toxemia".

Under the general title of "INFECTION" the following etiologic factors appeared: "lobar pneumonia", 1 case; "bilateral bronchopneumonia", 1 case; bronchopneumonia, 1 case; "puerperal metritis", 1 case: "peritonitis", 1 case; paralytic ileus, 1 case; septicemia from abortion, 2 cases; puerperal sepsis, 3 cases; "volvulus", 1 case; "pelvic peritonitis", 2 cases; "rectal abscess", 1 case; "influenza and syphilis", 1 case; "postoperative ileus", 1 case; and finally "acute generalized peritonitis" in 2 cases. In short, some type of infection in 19 cases!

The classification "HEMORRHAGE" was used to include these recorded diagnoses: "premature separation of placenta", 1 case; "shock", 3 cases; "puerperal hemorrhage", 1 case; "hemorrhage from abortion", 1 case; "total placenta previa", 1 case; and remotely, the diagnosis "cardiac failure" in 1 case. Two additional cases of "cerebral hemorrhage" might be construed remotely to be included under this heading. In brief, 10 cases placed possibly under the general category of "hemorrhage".

The term "EMBOLISM" was loosely used and might include the following 5 cases: "coronary embolism", 1 case; "cerebral embolism", 1 case; "post-partum cardiac embolism", 1 case; "embolism of both lungs", 1 case; and "multiple antenatal emboli both lungs" in another single case.

The misleading connotation "OTHER" causes of maternal death would include one case of "multiple neuritis".

If no further consideration were made than simple acceptance of the actual recorded major cause of death as listed upon the legal death certificate the following table would appear.

Table VII
The Principal Cause of Maternal Death
As Listed on Actual Death Certificates
Grand Rapids, Michigan 1937 - 1939

The General Class in which the Death Certificates would be grouped is as follows:	Number of Cases	Percentage of Cases
"Toxemia" death	12	25.5%
"Infection" death	19	40.4%
"Hemorrhage" death	10	21.2%
"Embolism" death	5	10.6%
"Other Cause" death (Multiple Neuritis)	1	2.3%
	47	100%

The Principal Cause of Maternal Death after individual case record analysis is listed in Table VIII. Comparison of Tables VII and VIII reveals the error evident in the full acceptance of the death certificate diagnosis as the final report. Further illustration of this inaccuracy is cited by the following specific examples.

On one death certificate was observed this diagnosis given as the principal cause of death: "Nephritis with Urinary Suppression, 3 days". A detailed study of this patient's hospital record reveals that the actual cause of death was: "the uterus was found ruptured from the tip of the fundus to its lower segment. Fetus free in abdominal cavity. Large amounts of free blood." The patient died on the fourth postoperative day, following Porro cesarean section. Hence the listed cause of death actually was but one of the patient's terminal symptoms rather than "massive hemorrhage and shock" which was the principal cause.

Another death certificate was signed by a coroner as "acute nephritis(?)" even though the coroner wrote "yes" after question, "autopsy?" Autopsy actually revealed "Incomplete abortion - acute metritis - B. Welchii infection - septicemia - acute urinary suppression - cerebral congestion and acute pulmonary edema." In short instead of "nephritis (?)" the cause of death was "Postabortal septicemia - B. Welchii organisms".

A further death certificate diagnosis gives as the principal fatal cause "Uremia" when actually the patient died 28 hours following a cesarean section from "postoperative surgical shock"!

The principal cause of death upon still another death certificate was listed as: "cardiac failure, 2 days." If this were actually true the case is worthy of single report in the literature. Jensen in his book entitled, "The Heart in Pregnancy", published 1938 by C. V. Mosby Co., page 131, lines 21 and 22, states: "In fact, for the grand total of 1,400,694 deliveries the ratio of cardiac deaths to delivery is 49 cardiac deaths per 100,000 deliveries." A more complete cause of death of this individual could have been listed as "mitral insufficiency complicated by pregnancy and terminating as 'cardiac failure'". This case was cited simply to draw attention to the relative inaccuracy of death certificate diagnoses as compared to the fuller clinical diagnoses. The reason an accepted clinical diagnosis is not transferred to the legal death certificate is difficult to understand. It is known that about some seven per cent of such maternal fatalities on basis of cardiac disease are accounted for each year in the U.S.A. Why should the "kind of heart disease" be omitted from death certificates?

The only unmarried woman who died in this series had listed on her death certificate "acute hemorrhagic nephritis" as the principal cause of death. The hospital course and clinical history reveals, "incomplete septic abortion terminating as generalized septicemia".

The "influenza and syphilis" case proved by autopsy to have: multiple small early pulmonary emboli - R. kidney, enlarged pale and edematous - L kidney appears normal". More pertinent was observation: "multiple air bubbles in lung capillaries". The clinical course of this 4 months pregnant patient (delivered but 10 months before from her first pregnancy) was: "headaches for 2 days, anuria 24 hours, weakness 2 days, irrational and semi-comatose - gradual deep coma and death."

BP 120/62 - TPR 98.4-86-14 and with no further unusual temperature deviation; being treated with neosolvarson; and slight trace albumin in urine last 6 days. In face of the post-mortem findings - "acute cardiac dilatation" - and in spite of no mention of coronary arteries or the thoracic aorta - the more logical cause of death must be considered as "coronary occlusion, luetic basis" and the possibility of a fatal antiluetic drug response cannot be entirely ruled out. In short, these details are presented to illustrate the case of adding "influenza" to a death certificate. Further evidence against the diagnosis "influenza" was a leucocyte count of 13,300 with a 72% polymorphonuclear shift! This laboratory work was done upon hospital admittance, 8 hours before death. This case, along with others among this series, would have added interesting data to any clinico-pathological conference.

A fatality listed as "nephritic anuria" actually died, 9 hours later following cesarean section, from surgical shock. The clinical course in this case revealed "a continuous fall of blood pressure in spite of supportive treatment". Why, in the face of such facts, was the former irrelevant symptom given as the principal cause of death?

A Summary of Cause of Maternal Death after Record Analysis

The principal causes of maternal death, as listed after detailed record survey of each individual case, permits the evidence demonstrated in Table VIII. Prior to construction of such a table the cases were grouped as maternal deaths due to direct complications of pregnancy and labor (44 cases) and diseases incidental to pregnancy (3 cases). The latter group includes the following summarized three cases:

Case 1.--Aged 24, married, primigravidum, pregnant 6 months, admitted to hospital C with history of acute upper respiratory disease for 3 days, pain in chest day before admittance. TPR-102-130-48. Patient cyanotic dyspneic-consolidation signs base R. lung- X-ray revealed bilat-bronchopneumonia. Wbcs-12,500. Downhill course. Labor began 8 hours after admittance. Delivered a living female child after one and one-half hour labor. Mother died four and one-half hours after delivery. Baby expired shortly after mother. This death, from bilateral bronchopneumonia complicated by pregnancy, is hereafter listed as "diseases incidental to pregnancy".

Case 2.--Aged 26, married, primigravida, pregnant 7 months, admitted to hospital A with clinical history of 10 days, "numbness and tingling finger tips, toes and end of nose: slurred speech, loss of bowel control, paralysis of left leg - abdominal pain with nausea and vomiting. Three consultants advised terminating pregnancy. Cesarean section performed day after admittance. Patient progressively became worse. Died 6 days after operation, respiratory failure type of death. Multiple laboratory tests. Autopsy (limited to abdomen) negative. Special studies of sections of sciatic nerve negative. Clinical diagnoses: "Landry's ascending paralysis? acute multiple sclerosis? poliomyelitis and death certificate signed as "multiple neuritis". This maternal death was hence included only in that group of fatalities caused by "diseases incidental to pregnancy".

Case 3.—Aged 32, married, secundigravida, when 5 months pregnant went to LMD with CC of chronic constipation and rectal bleeding for 8 months; treated by LMD for rectal abscess to control rectal bleeding which had been more profuse for 1 month. Admitted hospital C, acutely ill; followed very septic course. Diagnosed "toxic encephalitis" by neurologist. A large "hystero-rectal" and "pelvo-rectal" abscess on R. anal margin incised and drained 18 days after admittance. Approximately 2 weeks later a cecostamy was done to relieve intestinal obstruction. Day after last surgery patient delivered a previable infant after a 3 hour labor. Mother died about 18 hours after abortion. Autopsy revealed "multiple perforations throughout intestinal tract, involving large and small intestines. Mesentery similarly perforated. Acute Pyonephrosis - marked septicemia and generalized peritonitis". Death certificate included these diagnoses but "rectal abscess" leads the list of principal causes of death. This case is included under "diseases incidental to pregnancy".

Therefore the above 3 cases were subtracted from Table VIII and are separately listed. In the instances of the "influenza and syphilis" cases, the "cardiac failure" and the "volvulus" case, these patients' deaths would appear to be more directly related to pregnancy status and were therefore left in the category "direct complications of pregnancy". Prior to inclusion in this group each case was discussed with prominent obstetricians of New York City.

Table VIII
Cause of Maternal Death*
Grand Rapids, Michigan
1937 - 1939

Cause of Death	Number of Cases	Percentage
Toxemia	8	18.2%
Infection	17	38.6%
Hemorrhage	11	25.0%
Embolism	7	15.9%
Other	1	2.3%
	44	100%

Diseases Incidental to Pregnancy included the aforementioned bronchopneumonia with a 6 months' pregnancy; the "ascending paralysis" case with a 7 months pregnancy and the "septicemia case" associated with 5 months' pregnancy and "rectal abscess".

*Determined after analysis individual case records.

Table VIII can be subdivided as follows:

Toxemia		**Infection**	
Eclampsia	5 cases	P.O. Lobar pneumonia	1 case
Hyperemesis gravidarum	1 case	P.O. Bronchopneumonia	1 "
Preeclampsia	1 "	Septicemia, postabortal	9 cases
Acute yellow atrophy of liver	1 "	Puerperal sepsis	4 "
	8	P.O. Peritonitis	2 "
			17
Hemorrhage		**Embolism**	
Inversion of uterus	1 case	Decidual cell emboli (Multiple & Antenatal)	1 case
Ruptured uterus	3 cases	Pulmonary embolism	5 cases
P.O. Surgical shock	3 "	Paradoxical embolism (Assoc. with congenital aneurysm and patent foramen ovale - Rogers Disease)	1 case
Placenta previa	1 case		7
Ruptured Ectopic Pregnancy	1 "	**Other causes**	
Shock and Hemorrhage (Post accouchement force)	1 "	Mitral insufficiency with decompensation	1 case
Postabortal Hemorrhage	1 "		
	11	TOTAL	44 cases

Infection as the Cause of Death

The subheadings postabortal septicemia and puerperal sepsis account for cause of death in 13 of these 17 patients. Four of the septic abortions died at hospital A; one case at hospital B, and 4 cases at hospital C. One case of puerperal sepsis succumbed in hospital A, another at her home, and the remaining two cases at hospital C. It is not amiss to emphasize that in 4 instances of "infection death" at hospital A the note was made, "B. Welchii". Furthermore, the typical description of the course of all four cases is compatible to the diagnosis "B. Welchii" being the principal etiological bacteria involved in these deaths. Without doubt those in charge of this hospital would wish to check their technical procedures and study possible other fatal surgical cases. Perchance the ultimate explanation will explain this more than usual incidence of mention of the gas bacillus infections within this hospital.

The lobar pneumonia case occurred at hospital C. This patient received 8 m. of pituitrin after episiotomy. She gives a 2 hour history of gas analgesia and anaesthesia and frequent notations of vomiting were made during the anaesthesia. Required 4 ampoules of ergot to control bleeding after a forced labor. Patient expired 17 days after delivery and the autopsy revealed a "subphrenic abscess. Hydrothoras. R. pulmonary collapse".

The postoperative bronchopneumonia death occurred at hospital A, eleven days following classical cesarean section and sterilization. The indication for the operation was primarily sterilization done on basis of "Pulmonary stenosis". The Autopsy made no mention of any abnormal heart pathology! It was summarized as "bilateral pneumonia - recent cesarean section - slight bilateral hydronephrosis and cholecystitis with stones".

One postoperative peritonitis occurred at hospital A. This surgery again included cesarean section and sterilization. Further details relative to cesarean section will be made in the companion paper accompanying this survey. The second postoperative peritonitis occurred at hospital C following surgery done to treat "volvulus" complicating a 6 months' pregnancy. It was of interest to note that this latter patient gave a history of two major abdominal operations plus mention of "adhesions on 5 occasions". It was difficult to decide whether these "5 occasions" should be added for a total of 7 abdominal operations. Nonetheless, the pregnancy definitely could be said to have brought on the abdominal crisis and ultimate catastrophe.

Hemorrhage as the Cause of Death

Hemorrhage or its associated states of shock accounted for the second largest number of maternal deaths, in 11 instances. An unusual case of "inversion of the uterus" occupies one cause of death which occurred at hospital C. The patient was delivered at home 6 hours before hospital admittance. Note was made of "failure of placenta to deliver"! The methods used to deliver the placenta were lacking in the record. The patient died 35 minutes after hospital admittance and upon admittance the uterus was completely inverted with the placenta still partially attached.

On case of ruptured uterus was encountered at each of the three hospitals. Three cases of postoperative "surgical shock" followed cesarean section at hospital C. These will be discussed in the companion paper to this survey. Hospital C reports one case of postabortal hemorrhage and an additional case of hemorrhage from total placenta previa. Eight of the eleven hemorrhage cases occurred at hospital C; one at hospital A; and the remaining 2 cases at hospital B.

The ruptured ectopic case died at hospital B. Without rancor and with candor this patient expired because almost the entire responsibility of this case rested upon an intern who diagnosed the case but was unable to secure prompt attention for it, other than transfusion, over a 4 hour period.

A severe "shock and hemorrhage" followed an accouchement force delivery at hospital C. The patient, a primigravida, was taken to the operating room after a brief first and second stage. Forceps applied. Third degree tear sustained and repaired. Bled profusely for 14 hours prior to manual removal of the placenta. Died 2 hours after removal of the placenta.

Embolism as a Cause of Death

Three of the six cases of embolic death occurred in the homes of patients and in two of these instances after the patient had been discharged from a hospital following delivery. An unusual case of "multiple decidual cell pulmonary emboli", occurring in the antenatal period of a woman 8 months pregnant with twins, saw its termination in hospital C. Hospital A reports a case of "pulmonary embolism" and the autopsy makes note of "ruptured varices in the lower uterine segment". A second "pulmonary embolism" death followed spontaneous delivery at hospital A.

The other causes of maternal death were discussed in this survey under the heading "death certificate diagnoses".

Autopsies

Twenty-three autopsies were performed among this series of 47 fatalities.

The Mode of Delivery

The method chosen for delivery included natural spontaneous delivery in but 9 instances and 3 of these occurred in the home and three each at hospitals A and C.

Hospital care either during or following septic abortion took place in hospital A, 4 cases; hospital B, 1 case; and the remaining 4 cases at hospital C.

One premature delivery occurred at hospital B and four at hospital C.

One Porro cesarean section was done at hospital C; three classical sections at hospital A and four fatal classical sections at hospital C.

Death followed labor induction via rupture of membranes in 1 case at hospital A. High forceps delivery was done on one occasion at hospital B (after local M.D. had failed at intrauterine forceps applications and version with attempted extractions for 2 hours in the patient's home). High forceps were used on 2 occasions after manual dilatation of cervix at hospital C.

Low forceps were reported in 2 fatal cases at hospital C and once in a home case. One intramortem cesarean section (really 20 minutes after death) was done at hospital C.

Two version and extractions after manual dilatation of the cervix took place at hospital C.

One therapeutic abortion case resulted in a fatality at hospital A while the same hospital reports one death each following "version and extraction" and "intraovular bagging" in the latter case, to treat a compound presentation with a prolapsed arm.

Inasmuch as this study is primarily a survey no recommendations will be made. The careful hospitals will profit, however, by a review of this portion of the survey!

Hospital C experienced but 4 maternal deaths in this 3 year period - although a fifth case did succumb after being discharged home. Two of this hospital's fatalities followed severe accouchement force by referring members outside its staff prior to bringing these 2 cases to this hospital while a third death, ectopic pregnancy, resulted without benefit of opinion or advice regarding its management from the obstetric staff. Therefore, actually but 1 maternal death in 3 years occurred under supervision of those doctors regularly using this hospital for delivery! This is an unusually fine record in the face of 1581 deliveries over a three year period.

The Progeny of 47 Maternal Fatalities

There were 4 sets of twins in this series. There were but 15 infants born of these mothers that survived beyond their neonatal period. Oddly enough only three of this group of 15 infants were female.

The table below (Table IX) illustrates the fate of the infants of these maternal patients who succumbed before, during, or after their deliveries.

Table IX
Fate of Infants Among 47 Maternal Fatalities
Grand Rapids, 1937 - 1939

Sex		Hospital A	Hospital B	Hospital C	Home
Male Infants	Alive	4	1	6	1
	Neonatal Deaths	0	0	4	0
	Stillborn	6	2	6	0
Female Infants	Alive	0	0	2	1
	Stillborn	0	2	2	0
Previable Fetuses		5	2	6	
Fetus died in utero		1	0	0	1

PART II
THE STILLBIRTHS AND NEONATAL DEATHS
Grand Rapids, Michigan
1937 - 1939

A study of stillbirths can be used to reveal a suggestive index of serious maternal morbidity. The following table (No. X) was developed to bring into relief the number of stillbirths in each institution as related to its total number of deliveries.

Table X
Number of Stillbirths as Related to Total Deliveries
Grand Rapids, Michigan
1937 - 1939

	Institution														
	A			B			C			Home			All City		
Year	TD	RSB	NRSB	TD	RSB	NRSB	TD	RSB	NRSB	TD	RSB	NRSB	TD*	RSB	NRSB
1937	830	19	8	517	9	8	716	19	8	833	27	1	2896	74	25
1938	835	17	10	544	9	5	786	22	10	852	26	2	3007	74	27
1939	935	25	10	570	13	6	750	18	10	640	19	0	2895	75	26
TOTAL	2600	61	28	1631	31	19	2252	59	28	2325	72	3	8798	223	78

*approximate

T.D. - Total Births. In case of all city determined by adding A+B+C+H (obtained by subtracting the number of live births to ascertain approximate number of total births for home) equals as accurate a total number of deliveries as can be determined with available data.

RSB.- Resident stillbirths. NRSB - Non -resident stillbirths. (The number of stillbirths was obtained directly from death certificates.)

There were 301 stillborn infants. This data was garnered by copying the details of each stillbirth death certificate over a period of three years. Upon allocatión to residence 223 stillborns were found to have been borne of resident patients while the remaining 78 cases were delivered from non-resident patients in Grand Rapids, Michigan, and the large hospital in East Grand Rapids. The further allocation of these stillbirths by residence to each institution of delivery is shown in table X. It is to be observed that although the number of stillbirths delivered in the homes of Grand Rapids is correct that the absolute number of total deliveries could not be determined save to within a possible error of approximately 1 to 2 per cent. This difficulty naturally throws out the absolute accuracy of the all city figure, total births, about 3%. Nonetheless, it is accurate to the point of practicality. All three hospital figures are accurate. It was the cumbersome and intricate "adjustment" of statistics that precluded fuller accuracy for home deliveries and hence the all city total.

The non-resident stillbirths, included under home deliveries, occurred in another smaller institution in the city of Grand Rapids. Because this number was so small it was left in the "home" category.

If the total number of stillbirths were added to the total reported live births, prior to "adjustment", the total deliveries would be (8798 + 301) 9099 cases and the stillbirth mortality rate would be 33.0 per 1000 deliveries. This figure crudely but practically translated simply means that approximately one of every 30 deliveries is destined to terminate as a stillbirth. This figure covers the 3 year period. The relationship of maternal complications to this stillbirth problem is more than casual. Better maternal antenatal care with conservative and more refined delivery techniques plus skillful management in the first two stages of labor would materially lower this stillbirth incidence and, indirectly, decrease maternal morbidity and mortality.

The relationship of maternal morbidity, and, in some cases, maternal mortality, to the stillbirth incidence is depicted in table XI. In the effort to avoid multiple charts this data was presented for the entire 3 year period, for each institution of delivery. (In passing it may be well to draw the attention of the Kent County Medical Society to the wealth of accumulated data, made available by this survey, which might be used advantageously for a more complete pediatric or infant mortality survey as a follow-up to this present analysis.)

One hundred and twenty-one death certificates of the 301 stillbirths, 40.0%, gave no other possible etiologic factor than the simple statement of "stillbirth" to explain the cause of death. The remaining 180 death certificates specified additional explanations as possible causes for the stillborn deaths.

Twenty-six monsters, or infants with serious congenital anomalies, were reported.

Table XI
Cause of Death Noted on Stillbirth Records
Other Than Statement "Stillborn"
Grand Rapids, Michigan 1937 - 1939
311 cases

	Hospital A	Hospital B	Hospital C	Home	All City
No Other diagnosis on death certificate	22	43	30	26	121
Monster, serious anomalies	9	0	8	9	26
Placenta Previa	6	0	5	5	16
Asphyxia neonatorum	6	0	2	2	10
"Macerated"	4	1	0	8	13
Maternal Diabetes	0	0	1	0	1
Intrauterine asphyxia	3	0	1	1	5
Ruptured Uterus	0	0	1	0	1
Cord complications					
Knots or twists	0	1	0	3	4
About neck or body	6	1	4	1	12
Prolapse	2	0	1	3	6
Thrombosis	0	0	1	0	1
Placental defect	1	0	0	0	1
"Difficult labor"	2	0	4	1	7
Abruptio placenta	2	0	3	1	6
Maternal toxemia	7	0	6	3	16
Constriction rings	1	0	2	0	3
"Prematurity"	13	3	9	5	30
Thymus enlargement	1	0	0	0	1
Maternal syphilis	0	0	1	1	2
Cesarean section	0	0	2	0	2
Hydramnios	0	0	1	0	1
"Breech Delivery"	2	0	1	2	5
Cephalo-pelvic disproportion	1	0	0	1	2
"Forceps delivery"	0	0	2	1	3
Maternal pyelitis	0	0	1	0	1
Cerebral hemorrhage in infant	0	1	1	0	2
Congenital atalectasis	0	0	0	1	1
Face presentation	0	0	0	1	1
Maternal trauma	1	0	0	0	1
Totals	89	50	87	75	301

Cord complications accounted for the third largest number of stillbirths, in 23 instances. Some fetal salvage may have been gained possibly by more adequate maternal care in the antepartum and intrapartum periods in the cases of stillbirth associated with placenta previa, 16 instances: "asphyxia neonatorum", 10 instances; difficult labor, 7 instances; abruptio placenta, 6 cases; maternal toxemia of pregnancy, 16 cases; "constriction rings", 3 cases; "prematurity" in 30 cases; maternal syphilis, 2 cases; cesarean section, 2 cases; "breech delivery", 5 cases; cephalo-pelvic disproportion in 2 cases; "forceps" delivery in 3 cases; maternal pyelitis, 1 case; and face presentation in one case. In brief, 127 stillborn infants, 42.2% of the stillborns, gave suggestive evidence that associated maternal complications were possibly responsible for the status of stillbirth. <u>If but one half of this number could have been salvaged at least 62 more pregnancies would have been terminated successfully</u>!

NEONATAL MORTALITY
As Related to Maternal Morbidity

Another adequate index which suggests maternal morbidity trends can be derived from a detailed survey of neonatal deaths, those occurring under the age of one month. The ancient obstetric aphorism, "the first hour of life is the most critical", is illustrated eloquently in the following findings in this fraction of the survey. Only those portions of the neonatal statistics which might have a direct, or possibly indirect, bearing upon maternal morbidity will be considered, viz: time of survival after birth (in this study broken down into considerable detail); and the associated causes of death as listed upon each of the neonatal death certificates.

The neonatal death certificate information was copied from the legal duplicate death certificates obtained at the City Health Department. The entire group of death certificates, all ages, were reviewed on 2 occasions to glean this information. Insofar as possible the statistics were checked further with those reported previously by the Grand Rapids City Health Department.

There were 334 neonatal deaths in the city of Grand Rapids during the 3 year period of this survey. When the total live births for this period (as supplied by the City Health Department), or 8798 live births, the neonatal mortality rate was found to be 37.9 per 1000 live births. This figure expressed in plain terms indicates that approximately one of each 26 infants, born alive, died before they were 30 days old, in Grand Rapids, during this 3 year period. Table XII portrays the neonatal deaths as correlated to years of their occurrence.

Table XII
Neonatal Deaths in Grand Rapids
1937 - 1939

Death occurred	1937		1938		1939		Three year period	
	No.	%	No.	%	No.	%	No.	%
Under 1 hour	24	20.8	20	16.8	19	18.8	63*	18.8
Under 1 day	47	40.8	57	48.3	50	49.6	154	46.1
Under 1 week	32	27.8	17	14.3	13	12.9	62	18.5
Under 2 weeks	5	4.6	9	7.6	10	9.9	24	7.1
Under 3 weeks	0	0	8	6.7	5	4.9	13	4.2
Under 4 weeks	7	6.0	7	6.3	4	3.9	18	5.3
Totals	115	100%	118	100%	101	100%	334	100%

*Includes 1 case, infanticide, found frozen in waste container. This case will be arbitrarilly listed in deaths under 1 hour in "home" column.

These 334 neonatal deaths included 108 non-resident cases and 226 resident cases. The sexes were divided between 202 males to 132 females.

Interest of obstetrical significance to physicians of Grand Rapids is observed in that 217 infant deaths occurred among these 334 neonatal fatalities before they were one day of age. This figure represents 64.9% of all the neonatal deaths. In short, approximately two of every three neonatal deaths in Grand Rapids occurred before those newborns were one day old! And further, 279 instances of the total 334 neonatal deaths took place before the newborns were one week old, or approximately 5 of every 6 neonatal deaths occurred in the first 7 days.

The obstetrical implications of this series of neonatal deaths is of sufficient importance to permit further calculations. These are presented in Table XIII. Table XIII portrays the neonatal mortality rates of each neonatal length of life group; and, furthermore, the interpretation of such figures, via the simplest expression possible, is made through a determination of the approximate ratio of neonatal death to the number of live infants.

Table XIII
Neonatal Mortality Rates*
Correlated to Length of Life After Birth
(The Approximate Chance of Neonatal Death
at Various Time Intervals in Neonatal Period)
Grand Rapids, Michigan 1937 - 1939

Infant Death Occurred Under Age of	Number of Cases	Neonatal Mortality Rate /1000 Live Births	Approximate chance of Newborn Dying During Each Period
1 Hour	63	7.2	1 of each 139 live births
1 Day	154	17.5	1 of each 57 " "
1 Week	62	7.4	1 of each 136 " "
2 Weeks	24	2.7	1 of each 370 " "
3 Weeks	13	1.5	1 of each 666 " "
4 Weeks	18	2.0	1 of each 500 " "
Any time under one month (cumulative)	334	37.9	1 of each 26 " "

An illustration of the last column is furnished in the statement, e.g. that if a child was newly born during the interim of 1937 - 1939, in Grand Rapids, its chance of death during the first day of its life was 1 to each 57 infants born at that time. The older the infant becomes with the passage of time just so does its chance of death diminish.

However, if the values were reviewed cumulatively the chance of any newborn infant death born among this group during the 3 year period, any time before the end of the second week was approximately 1 in 29 chances. Similarly, the chance of neonatal death any time before the age of 30 days was approximately 1 in 26 chances. If the physician were to keep in mind such usual, unfortunately, figures he would be more inclined to pause after he has delivered his 25th pregnancy!

*Based upon total live births reported from Grand Rapids, 1937 - 1939 (8798 live births).

It is of singular obstetric concern to consider Tables XIV and XV in which an evaluation of the number of neonatal deaths was made for periods of time under one hour and under one day as they took place in each institution of delivery. These figures were inclusive for the 3 year period. They were further subdivided into smaller time fractions in both tables.

Table XIV
Number of Neonatal Deaths Under the Age of One Hour
Grand Rapids, Michigan, 1937 - 1939

Length of Life After Birth		Institution of Delivery Hospital A	Hospital B	Hospital C	Home	All City	Cumulative Number	Cumulative Percentage
All under 1 hour	5 mins.	2	6	3	1	12	12	19.0
	15 "	4	5	5	2	16	28	44.4
	30 "	5	2	3	3	13	41	65.0
	45 "	1	1	1	2	5	46	73.0
	60 "	3	3	6	5	17	63	100%
Total 1 hour or less		15	17	18	12	63		

A glance at Table XIV reveals that 12 of the 63 newborn deaths (19%) took place in the first 5 minutes of those infant lives; that 28 of the 63 cases (44.4%) died on or before age of 15 minutes and that 41 of the 63 infantile patients (65%) succumbed before they were 30 minutes of age! Approximately 2 of each 3 neonatal deaths, occurring in the first one hour of life, actually took place in the First Half Hour!!

Six of each 10 neonatal deaths, happening in the first day of life, occurred before the age of 6 hours or in the first fourth of that day. See Table XV.

Table XV
Number of Neonatal Deaths
Under the Age of One Day
Grand Rapids, Michigan, 1937 - 1939

Length of Life After Birth	Institution of Delivery Hospital A	Hospital B	Hospital C	Home	All City	Cumulative Number	Cumulative Percentage
1 hour or less	15	17	18	13	63	63	29.0
3 hours	10	2	19	2	33	95	44.2
6 "	10	4	16	4	34	130	59.9
9 "	13	3	10	2	28	158	73.2
12 "	6	2	6	0	14	172	79.2
15 "	2	0	0	0	2	174	80.1
18 "	0	0	3	1	4	178	82.0
21 "	0	0	5	0	5	183	84.3
24 "	12	4	12	6	34	217	100%
Total 1 day or less	68	32	89	28	217		

The number of neonatal deaths under the age of one day in Hospital C was nearly three times as great as that in Hospital B or in the Home and 21% greater than hospital A.

Cause of Death

The principal cause of death among the 334 neonatal infants was "Prematurity" according to analysis of the entire group of death certificates. Prematurity was given as the cause of death in 199 instances, 59.5%, and was the only cause of death listed in 157 cases of this latter subgroup. In 42 instances there was given an associated or more specific diagnosis. In such cases the associated diagnosis was given priority for the sake of clarity. However, to avoid omitting prematurity among this group of 42 infants special consideration was tendered this diagnosis by the formulation of Table XVI. In this chart the length of life of these 2 classes of "prematurity" diagnoses was compared.

Three of each four newborns, whose death certificates were signed "Prematurity" as the only cause of death, died on or before they were 24 hours of age. See column 3, cumulative per cent, in Table XVI.

Table XVI
Prematurity Among Neonatal Deaths
Length of Life After Premature Birth
Grand Rapids, Michigan, 1937 - 1939
199 cases

Length of Life	Prematurity, the only diagnosis			Prematurity, associated with other major diagnoses		
	No.	Cum. No.	Cum. %	No.	Cum. No.	Cum. %
1 hour or less	34	34	21.6	7	7	16.6
1 day	95	129	75.7	21	28	66.6
1 week	16	145	92.3	5	33	78.6
2 weeks	7	152	96.1	5	38	90.5
3 weeks	2	154	97.4	1	39	92.8
4 weeks	3	157	100%	3	42	100%
Total 1 month or less	157	157	100	42	42	100

Cum. No. - Cumulative Number
Cum. % - Cumulative Percentage

Inasmuch as the 42 prematures mentioned in the right side of Table XVI have associated diagnoses, and many of these of pertinent obstetrical interest, the secondary diagnosis was considered. It was of interest to observe that, in this group, the prematures were older, for the majority of cases, all but 7 cases, in instances where age was given, were 7½ months or over.

The accompanying diagnoses bearing obstetrical complications in the group of 42 prematures included: acute hydramnios, 4 cases (twins in 1 case were delivered by cesarean section); birth injury, 2 cases; maternal toxemia of pregnancy, 6 cases; breech delivery in 5 cases; abruptio placenta, 4 cases; placenta previa, 3 cases; cesarean section with subsequent aspiration of mucus, 1 case.

Hence, in 25 instances of these 42 cases the diagnosis of neonatal death admitted direct maternal complications. The remaining neonatal prematures, 17 cases, were further diagnosed: bronchopneumonia, 3 cases; "circulatory failure", 1 case; "tetany", 1 case; entero colitis, 2 cases; icterus neonatorum, 1 case; hemorrhagic disease of the newborn, 1 case; "congenital atalectasis" in 7 cases, and "thymic" death in 1 case.

The total neonatal death certificates which provided diagnoses of obstetrical interest included the following:

Monsters, viable: lived 5 minutes, 4 cases; 15 minutes, 1 case; 30 minutes, 1 case; 45 minutes, 1 case; 1 hour, 1 case; and 2 cases each lived for 3 weeks. A total of 10 cases.

Birth injury was given as the cause of death in 23 instances (6.7% of series). These neonates succumbed 1 hour following delivery in 2 cases; 3 hours, 1 case; 6 hours, 1 case; 9 hours, 1 case; 21 hours, 1 case; 24 hours, 2 cases; 2 days, 6 cases; 3 days, 2 cases; 4 days, 3 cases; 5 days, 1 case; 6 days, 1 case; and 2 weeks, 2 cases. The specific birth injury was mentioned but once - a case of subdural hematoma.

Severe Internal Anomalies accounted for 12 neonatal deaths. These cases included the following malformations: congenital atresia of colon with obstruction, 4 cases; congenital malformation of the biliary ducts, 1 case; imperforate anus, 1 case; tracheo-esophageal fistula, 2 cases; atrena of ileocecal valve, 1 case; "abnormally large liver", 1 case; congenital absence of both kidneys and ureters, 1 case; and congenital malformation of the sigmoid, 1 case. Five of these cases submitted to surgery prior to their demise. All but 2 cases of this group lived 5 days or more.

Maternal Toxemia was mentioned 8 times in the entire series of 334 cases. Breech delivery was included in the diagnoses in 8 instances. Abruptio placenta was noted on 4 certificates. Placenta previa in mother accounted for 6 neonatal deaths. Cesarean section was noted on 3 infant death certificates. Acute hydramnios was mentioned on 4 occasions. Cord about infant neck, oddly enough, was listed in but one case as were "forceps delivery", "strangulation", and "congenital syphilis".

In the above mentioned cryptic terms one can see glimpses of serious maternal morbidity. The inexpert intrapartum care of women pregnant with monsters accounts for some morbidity. "Birth injury" diagnosis covers all too numerous sins of commission in the nature of accouchement force; unnecessary version and extraction maneuvers and forceps application; manual dilatations of the cervix; over sedation, followed by forced deliveries after "induced labors" during parturition; and, possibly more important, the active neglect of the physician to adhere to "watchful waiting".

Hydramnios, chiefly on the increased side, may not call necessarily for active intervention. The statistical aphorism "Polyhydramnios - 70% monsters; 10% twins; and 10% large baby" calls for more specific antenatal diagnosis prior to intervention.

Conservative treatment of maternal toxemia with more emphasis upon the medical approach increases materially the per cent of neonatal salvage. In this same category calling for matured management of labor falls the maternal complications of abruptio placenta, placenta previa, borderline pelves - especially in primigravida cases, and in breech presentations. Further mention regarding cesarean section is reserved for the survey study of this operative procedure.

General

In general the physicians and hospitals of Grand Rapids were found to have rendered adequate service (based upon statistical evidence) to their obstetric patients. The City Health Department of this city reviews annually its low mortality rates with accountable pride in the doctors of this city. Nevertheless, there are few records so excellent they cannot be bettered. When considered in cold penetrating study this adequate service, in spite of its merit, was resolved to the delivery of 8798 women among whom, or in the families of, there occurred 682 tragedies: 47 maternal deaths, 301 stillbirths, and 334 neonatal deaths in the 3 year period 1937 - 1939.

A larger number of radical obstetric procedures, used to affect delivery, happened in hospitals A and C.

Consultation, in the fatal group of 47 obstetric cases, as a general rule was adhered to after the complication became serious in aspect. A conservative estimate is that 50% of the radical procedures and overzealous methods of treatment used could have been avoided if those referring physicians had received cooperative advice, tempered with judgment, prior to a more serious state of condition in the new mothers. In brief, early consultation in early states of pregnancy complications or in patients among whom complications are suspicioned.

In hospitals A and C, as in the "home" group, there was obviously a laissez-faire policy in reference to individual physician judgment.

Hospital B is complimented upon the cohesion of its obstetric staff as evidenced by earlier consultations and a tendency to utilize less radical obstetric procedure. The record of this institution is enviable.

As will be shown in the companion paper to this survey the incidence of operative interference was highest at hospital A. It was not for this reason alone that this statement was necessary. Rather, more serious was the quality of judgment and surgical skill in conjunction with a less closely knitted and cooperating staff. A minor revision of staff rules and the hospital staff personnel itself, in some degree, would appear to have been (after statistical analysis) sufficient to correct this less enviable record.

The purpose of this survey was simply to demonstrate facts. The above statements are to be considered not as recommendations but as straightforward statements of fact based entirely upon statistical evidence.

The maternal health committee of the Kent County Medical Society, the doctors, the hospitals, the health authorities of the City Health Department, and the agents of the State Health Department were most cooperative and helpful to the surveyist. For this most excellent consideration and assistance the surveyist was grateful. He was especially thankful for the indulgent patience of the doctors and hospitals.

Respectfully submitted

Clair E. Folsome, M.D.